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## PUBLICATIONS ABSTRACTS

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### **Electro-Optic and Second Harmonic Generation Materials, Devices, and Applications II**

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#### Abstracts:

Paper #: 3556-01

New NLO material in IR region:  $\text{CsGeCl}_3$ , pp.1-3

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Abstract: An idea to search for a novel infrared NLO crystal from insulating compounds is presented.  $\text{CsGeCl}_3$  has been synthesized by a modified route, and characterized by X-ray powder diffraction. This insulating compound with a room temperature conductivity of  $5 \times 10^{-9} \text{ S/cm}$  (compressed pellet) has shown both excellent transparency in infrared region (0.4 - 20 micrometer) and SHG effect 4.5 times stronger than that of KDP. !4

Paper #: 3556-02

Highly efficient eyesafe output from noncritically phase-matched KTP optical parametric oscillator, pp.4-7

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**Abstract:** We have developed a high efficient, all-solid-state approach by using potassium titanyl phosphate (KTP)-based optical parametric oscillator to frequency shift Nd:YAG 1.064 micrometer to eye-safe wavelength at 1.57 micrometer. To reduce the threshold of KTP OPO, we reflected back the deleted pump wave according to original light path. The maximum energy conversion efficiency 64% and quantum conversion efficiency 94% was achieved when the OPO was pumped by Nd:YAG laser at 1064 nm. !9

Paper #: 3556-03

New class of nonlinear optical crystals R<sub>2</sub>CaB<sub>10</sub>O<sub>19</sub> (RCB), pp.8-13

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**Abstract:** A new series of mixed borates of rare-earth elements and calcium with the composition R<sub>2</sub>-2\$/CaB<sub>10</sub>O<sub>19</sub>-19\$/ (where R represents rare-earth element) has been identified in the system R<sub>2</sub>-2\$/O<sub>3</sub>-3\$/-CaO-B<sub>2</sub>O<sub>3</sub>-3\$/. These isostructural compounds exhibit a powder second harmonic generation (SHG) effect about twice larger than that of KDP (KH<sub>2</sub>PO<sub>4</sub>). The crystal structure of La<sub>2</sub>-2\$/CaB<sub>10</sub>O<sub>19</sub>-19\$/ (LCB), one member of the RCB family, has been determined by single crystal X-ray diffraction analysis. The compound crystallizes in the monoclinic system, space group C<sub>2</sub>, with a equals 11.043(3)angstrom, b equals 6.563(2)angstrom, c equals 9.129(2)angstrom, \$alpha equals \$gamma equals 90 degrees, \$beta equals 91.47 degrees, and two formula units per cell. LCB melts congruently with a melting point of 1065 plus or minus 2 degrees Celsius. Single crystals of LCB and Nd doped LCB in centimeter size have been grown from the

stoichiometric melt. The preliminary results on properties of LCB are presented. !9

Paper #: 3556-04

Computer-assisted design for nonlinear optical crystals, pp.14-20

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Abstract: Based on the anionic group theory, a computer-assisted material design system (CAMDS) has been developed and shown to be a highly efficient means for discovering nonlinear optical crystals. In this method, important optical properties of the target compounds (borates, for example), such as the  $d_{ij}$  coefficients, refractive indices and energy bandgap, are calculated so that a prior evaluation can be made before experiments. The results have given a meaningful guide to ensuring experiments, which have led to our discoveries of KBBF ( $\text{KBe}_2\text{BO}_3\text{F}_2$ ) and SBBO ( $\text{SrBe}_2\text{BO}_3\text{F}_2$ ) in previous years followed by other members of the SBBO family in recent years. On the other hand, the system can also be used to evaluate the  $d_{ij}$  coefficients of the borate NLO crystals discovered recently whose  $d_{ij}$  coefficients have not been determined from experiment. !16

Paper #: 3556-05

Two new nonlinear optical crystals:  $\text{BaAl}_2\text{B}_2\text{O}_7$  and  $\text{K}_2\text{Al}_2\text{B}_2\text{O}_7$ , pp.21-23

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Abstract: The new nonlinear optical crystals

$\text{BaAl}_2\text{B}_2\text{O}_{12}$  and  $\text{KAl}_2\text{B}_2\text{O}_{12}$  are readily grown by top-seeded flux method.

$\text{BaAl}_2\text{B}_2\text{O}_{12}$  crystallizes in the rhombohedral space group  $R\bar{3}2$  ( $Z$  equals 3) in a cell of dimensions  $a$  equals  $b$  equals 5.001 angstrom,  $c$  equals 24.378 angstrom and  $V$  equals 528.01 angstrom<sup>3</sup>.

$\text{KAl}_2\text{B}_2\text{O}_{12}$  crystallizes in the trigonal space group  $P321$  ( $Z$  equals 3) in a cell of dimensions  $a$  equals  $b$  equals 8.530 angstrom,  $c$  equals 8.409 angstrom and  $V$  equals 529.9(2) angstrom<sup>3</sup>. The theoretical calculations and the measurement of nonlinear optical effect indicates that the two crystals are phase-matchable with the nonlinear optical coefficient  $d_{11}$  equals 0.75 pm/V for  $\text{BaAl}_2\text{B}_2\text{O}_{12}$  and  $d_{11}$  equals 0.48 pm/V for  $\text{KAl}_2\text{B}_2\text{O}_{12}$ . The birefringence of  $\text{BaAl}_2\text{B}_2\text{O}_{12}$  is  $\Delta n$  equals 0.063 and 0.068 for  $\text{KAl}_2\text{B}_2\text{O}_{12}$ . !7

Paper #: 3556-06

Growth and characterization of potassium lithium niobate crystals, pp.24-30

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Abstract: Tetragonal tungsten-bronze potassium lithium niobate crystals (KLN) were grown by vertical Bridgman technique. Transparent KLN crystals with 10 mm in diameter and 25 to 45 mm in length were obtained. Crystallization behavior from different KLN melts was studied. It was found that KLN crystals will stop growing after the melt composition changes to some critical value and other phases, such as  $\text{KNbO}_3$ ,  $\text{LiNbO}_3$  and  $\text{Li}_3\text{NbO}_4$ , crystallize at the same time. Inhomogeneity and cleavage of as-grown KLN crystals were discussed. !18

Paper #: 3556-07

Realizing intracavity frequency doubling and Q switching by KTP, pp.31-36

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**Abstract:** The electro-optic characteristics of the KTP crystal are analyzed in detail and Q-switched operation of a diode-laser- pumped Nd:YVO<sub>4</sub>/ laser is reported using an intracavity KTP crystal. The KTP crystal was used as both an electro-optic Q- switcher and a frequency-doubling crystal in type II phase matching for generating pulsed green beams. Compared with the conventional frequency-doubling and Q-switching configuration where a Q-switcher and a frequency-doubling crystal was needed, low loss and high efficiency characteristics were realized by only using KTP crystal in our experimental setup. With the new type of KTP crystal doped particular element, the great green pulsed output was obtained continuously for a long time with no sign of electrochromic damage. In this paper, we demonstrated a relatively new and compact intracavity frequency-doubled and Q-switched Nd:YVO<sub>4</sub>/ laser. The short- cavity laser was longitudinally pumped with a diode laser. !6

Paper #: 3556-08

Photoinduced bleaching and temporal stability of organic nonlinear optical materials in Langmuir-Blodgett films, pp.37-41

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**Abstract:** Three organic dyes, diazostilbenes (HPNA), phenylhydrazones (PD) and hemicyanine (DAEP), all have large hyperpolarizability  $\beta$  but different double bonds in their conjugated  $\pi$ -electron systems ( $N$  equals  $N$  in HPNA,  $C$  equals  $N$  in PD and  $C$  equals  $C$  in DAEP). We investigated stability of LB multilayers of the three dyes and found that the second harmonic generation (SHG) intensities from those samples reduced significantly within a few tens of days. On the other hand, the Raman intensities from the powder samples of three dyes due to the stretching modes of the double bonds and the UV absorption band from the LB multilayers of the three dyes corresponding to the original chromophores also decreased with increasing time of UV irradiation, confirming the breakdown (cleavage) of the double bonds (photo-induced bleaching) in all the three dyes. The SHG, UV-vis absorption and Raman experiments deduced the same sequence of stability:  $N$  equals  $N$  the worst and  $C$  equals  $C$  the best, suggesting that photo- induced bleaching effect, instead of deterioration of the film frameworks, could possibly be responsible for the instability of the optical nonlinear LB films through a second-harmonic resonant effect. !6

Paper #: 3556-09

Stability and optical properties of DMACB/PEK-c polymer films,  
pp.42-45

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Abstract: Preparation, Stability and the optical properties of DMACB/PEK-c film were reported. The films have good transmittance and improved stability. By quasi-waveguide method. The refractive indices of the film,  $n_e$  and  $n_o$ , were measured, which were 1.65800 and 1.63614 at 0.6328 micrometer, respectively; the film's electro-optic coefficients,  $\gamma_{33}$  and  $\gamma_{13}$  were also obtained, which were 80.80 pm/V and 32.88 pm/V, respectively. !2

Paper #: 3556-10

Synthesis of several novel multifunctionalized chromophores for second-order NLO, pp.46-49

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Abstract: 4-disubstituted-amino-phenylazo- $\alpha$ -cyanocinnamates with two or more functional groups (such as hydroxyl, allyl) at both ends of the molecule to be used as novel chromophores for second-order NLO polymeric materials are synthesized by diazonium coupling and Knoevenagel condensation. In this two-step method, the tediousness of functionalization at the electron-acceptor end is avoided by selecting  $\alpha$ -cyanoacrylate as electron-acceptor. The products are easy to purify, and the whole procedure is simple and time-saving, which facilitates the choice of polymer system for effective hardened NLO lattice in a broader range. !10

Paper #: 3556-11

Improved optical nonlinearity of poled phenylhydrazone-doped polymer films, pp.50-56

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Abstract: The optical properties of two kinds of corona poled polymer films, NDA (4-nitrobenzal-4-N,N-dimethylaniline) and a newly synthesized CNDA ( $\alpha$ -cyano-4-nitrobenzal-4-N,N-dimethylaniline) doped PMMA (polymethyl methacrylate) films were investigated with in situ



second-harmonic generation (SHG) measurement and UV-Visible absorption measurement. Optimum corona poling temperatures of the polymer films were found to be lower than glass transition temperatures of the materials. Under the optimum corona poling condition, the second-order nonlinear susceptibility  $\chi^{(2)}$  of CNDA/PMMA is larger than that of NDA/PMMA. The molecular second-order polarizability  $\beta$  of the CNDA was estimated to be about  $146 \times 10^{-30}$  esu from the measured absorbance and  $\chi^{(2)}$ . The relaxation of SHG intensity of CNDA/PMMA was slower than that of NDA/PMMA. We concluded that CNDA is a better dopant than NDA as a second-order nonlinear-optical material. !9

Paper #: 3556-12

Synthesis and characterization of a novel styrylthiophene monomer and corresponding heterocyclic polymer for NLO materials, pp.57-65

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Zhiwen Shi, Institute of Semiconductors, Beijing, China.

Abstract: A novel

(Trans)-7-(4-N,N-di-( $\beta$ -hydroxyethylamino benzene) ethenyl 3,5-dinitrothiophene (HBDT) monomer was synthesized and characterized. We also present in this paper an approach to synthesized processible, un-cross-linkable, and thermally stable heterocyclic polymer (Polyurethane) with the monomer covalently incorporated. The details of synthesizing the monomer and un-cross-linked heterocyclic polymer are presented. The un-cross-linked polymer exhibited good solubility in common organic solvents, permitting processing relevant to device fabrication. After being efficiently poled and cured, optical-quality films exhibited moderate nonlinearity and thermal stability. !7

Paper #: 3556-13

Modulated transmission property of bR film and its application on thresholding operation, pp.66-72

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**Abstract:** In this paper, we analyzed theoretically the modulated transmission property of bR film under two beams of light, yellow light and purple light, illuminate the bR film simultaneously. Using the transmission property of bR film, we can realize the winner-take-all thresholding operation. Based on this thresholding operation, we realized some useful optical signal process. !13

Paper #: 3556-14

Molecular first hyperpolarizabilities of two photoconducting merocarbocyanines, pp.73-83

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**Abstract:** The dot products  $\mu\text{-g}/\beta\text{-CT}$  of first hyperpolarizability and ground state dipole moment of two merocarbocyanines: 3-ethyl-5-(3-ethyl-2-benzothiazolinylidene)ethylidene-rhodanine (dye I) and 3-cyano-5-(3-ethyl-2-benzothiazolinylidene)-ethylidene-4-phenyl-2(5H)-furanone (dye II) were measured experimentally with the Solvatochromism and compared to the values obtained by AM1/FF calculation. The comparable result was also obtained by the measurement of second harmonic generation for LB film of dye II. The  $\mu\text{-g}/\beta\text{-CT}$  of dye II is larger than that of the famous NLO chromophore 4-N,N-dimethylamino-4-nitrostilbene (DANS). Through the calculation of the heat of formation of two dyes' various isomers, it is found that the most stable one is the (cis-, cis-) isomer which possesses the largest  $\beta$  value. The origin of large  $\beta$  values for dyes has been explained based on the two-level model from the investigation of the extended molecular conjugation length, change of charge distribution between the ground and first excited state and the analysis of the frontier molecular orbitals. In addition, Dye I is a quasi-two-dimensional chromophore while Dye II is a one-dimensional one, which can be explained by whether the electron-withdrawing group in dyes has mesoionic ring characteristic or not. !31

Paper #: 3556-15

Determination of the electro-optic coefficients of DMACB/PEK-c polymer films using the quasi-waveguide m-line method, pp.84-87

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**Abstract:** In this letter, we report a new electro-optic (EO) polymer film DMACB/PEK-c. After poling of the film the refractive indices  $n_{-t}$  and  $n_{-n}$ , viz. the in-film-plane and the normal-to-film plane indices of refraction at 0.63-micrometer and the thickness  $d$  were determined using the quasi-waveguide m-line method. The electric field-induced changes in the refractive indices of the film,  $\Delta n_{-t}$  and  $\Delta n_{-n}$ , were also independently measured when an electric field was applied normal to the film plane. The EO coefficients of the film,  $\gamma_{-13}$  and  $\gamma_{-33}$ , are found to be 32.9 pm/V and 82.6 pm/V respectively. !6

Paper #: 3556-16

Structural, dielectric, and optical properties of PT/PEK-c electro-optic polymer films, pp.88-92

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**Abstract:** A new electro-optic polymer film PT/PEK-c has been prepared and investigated. This kind of film, especially c-axis oriented one, possesses good nonlinear optical properties. The structure of the film after poling was analyzed by x-ray diffraction. The result showed that the film was c-axis oriented. The transmittance of a 2.33-micrometer-thick film was measured in the wavelength range 320 to approximately 900 nm by means of a recording spectrophotometer. The transmittance of the film exhibited a sharp absorption edge at 360 nm. The optical band gap of the film was found to be 3.06 eV. The dielectric properties of PT/PEK-c film were investigated in terms of the dielectric constant  $\epsilon_r$  and the loss factor  $\tan \delta$ . They were measured by a capacitance bridge in the frequency range  $1 \times 10^2$  to approximately  $3 \times 10^6$  Hz. The dielectric constant and the loss factor of a 2.33-micrometer-thick film at room temperature and 10 kHz frequency were determined to be 4.023 and 0.003, respectively. !4

Paper #: 3556-17

Square pyramidal coordination compound for SHG:  $\text{Zn}(\text{acac})_2(\text{PhTU})$ , pp.93-96

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**Abstract:** The title compound has been synthesized by reaction of  $\text{ZnCl}_2$ , acetylacetone (acacH) and phenylthiourea (PhTU), and characterized by a variety of techniques. This compound is completely transparent in the visible region, and shows a powder SHG (second harmonic generation) effect as strong as 10 times that of KDP. X-ray single crystal structure analysis reveals that the molecule possesses a square pyramidal configuration around zinc ion. The molecules are aligned almost parallelly in the lattice so that the geometrical superposition of the molecular dipole moment and the first hyperpolarizability ( $\beta$ ) are favorably enhanced, giving rise to a relatively strong macroscopic SHG effect. !3

Paper #: 3556-18

Synthesis and SHG effect of some cyclotriphosphazene derivatives, pp.97-101

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**Abstract:** Twenty derivatives of hexachlorocyclotriphosphazene were synthesized by substituted reaction. The structure of the cyclotriphosphazenes were identified by i.r. uv-vis, n.m.r. and elemental analysis, proving that they are fully substituted cyclotriphosphazenes. Kurtz powder determination of SHG showed that two of them displayed SHG effect. X-ray diffraction determination of  $\text{N}_3\text{-P}_3\text{-(OC}_2\text{H}_5)_6$  is presented to explain SHG effect. !6

Paper #: 3556-19

Synthesis and third-order nonlinear optical properties of square planar complexes with donor-metal-acceptor structure, pp.102-107

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**Abstract:** A new series of mixed-ligand (imine and dithiolate) metal complexes with square planar donor-metal-acceptor structure were designed and synthesized for the study of third-order nonlinear optical property. It was found that complexes containing 4,5-dimercapto-1,3-dithiole-2-thionate (dmt) ligand exhibit large third-order optical nonlinearity at 1064 nm. Their second molecular hyperpolarizability  $\gamma_{1111}$  is in the order of  $10^{-31}$  esu. The excited-state enhancement of the third-order nonlinear optical susceptibility of complex (Py) $_2$ /Pt(mnt) (Py equals pyridine; mnt equals maleonitriledithiolate) was observed when the sample was optically pumped by either a picosecond or a nanosecond pump beam at the wavelength of 355 nm. For the picosecond case, the temporal behavior of the enhancement is characterized by a fast and a slow component, which is attributed to population of the first excited state  $S_1$  and the second excited state  $S_2$ , respectively. For the nanosecond case, the enhancement of the nonlinearity is attributed predominantly to the first excited state  $S_1$ . The molecular hyperpolarizabilities of the first excited state  $S_1$  and the second excited state  $S_2$ , i.e.,  $\gamma_{1111}^{S_1}$  and  $\gamma_{1111}^{S_2}$ , were determined to be  $1.9 \times 10^{-31}$  esu and  $1.0 \times 10^{-30}$  esu, respectively, which are much larger than that of the ground state ( $\gamma_{1111}^g$ ) less than  $5.6 \times 10^{-33}$  esu. !16

Paper #: 3556-20

All-optical poling of several different molecular-design films with azobenzene chromophore, pp.108-112

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**Abstract:** Four different molecule-design films with azobenzene chromophore were investigated in our experiment, which

were the guest-host system, the side-chain system, the crosslinked system and the diazo side-chain system. The decaying processes of them were presented and compared in pair. The differences between them were explained with respect to their different molecule design. !10

Paper #: 3556-21

Reversible optical storage using all-optical poling technique in azopolymer film, pp.113-116

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Abstract: Employing all-optical poling technique, we propose a novel method of optical storage based on the mechanism of photoinduced isomerization and reorientation of azobenzenes. The recording of an optical binary image was experimentally demonstrated in an azo-dye doped polymer film. The recorded information can be permanently stored and also can be erased rapidly with a circularly polarized light. Furthermore, a wavelength conversion of optical image can be obtained using such method. !9

Paper #: 3556-22

Fabrication and characterization of corona-poled NPP polymer waveguides for second-harmonic generation, pp.117-121

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**Abstract:** A polymethyl methacrylate (PMMA) and N-(4-nitrophenyl)-(s)-prolinol (NPP) side-chain polymer waveguide was developed and corona poled for second-harmonic generation (SHG) devices. The nonlinearity decreases with time in the corona poled NPP polymer waveguide were characterized by the variation of the extraordinary and the ordinary refractive indices with time. The Cerenkov-type green second-harmonic (SH) radiation at 532 nm was observed successfully. !4

**Paper #:** 3556-23

Periodic domain-inverted and blue light frequency doubling in LiTaO<sub>3</sub> waveguide, pp.122-124

**Author(s):** Chuanyi Zang, Changchun Institute of Physics, Changchun, China;  
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**Abstract:** We have reported here domain inversion periodically by Si ion inducing  $\text{LiTaO}_3$  face of  $\text{LiTaO}_3$ , and obtained inversion depth of 5 micrometer by the improved process. The optimum dosage implanted and the optimum temperature of heat treatment are given, respectively. The forming reason of domain inversion of Si ion inducing  $\text{LiTaO}_3$  layer was preliminarily analyzed. For the first time to our knowledge, second harmonic generation was investigated for three waveguide devices, and obtained the highest output power of 50  $\mu\text{W}$  in the blue at 485 nm. !5

**Paper #:** 3556-24

Green SHG of periodically domain-inverted LiTaO<sub>3</sub> using one-direction heating, pp.125-127

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**Abstract:** We have increased the heat stability of periodically domain inverted by process improving for one-direction heating. Periodically domain inverted can be suffered from the heat treatment at 500 degrees Celsius, when the heating treatment at 500 degrees Celsius, the domain depth decreasing from initial linear becomes nonlinear compared with initial experiment results. The phenomenon of periodically inverted spikelike domains on  $\text{LiTaO}_3$  surface disappeared, and it means that this periodically domain inverted can be used to waveguide device. The efficient intracavity second harmonic generation (SHG) was investigated using the bulk material of periodically domain inverted  $\text{LiTaO}_3$  crystal, and 1 mW of green light at 532 nm

is obtained. !4.

Paper #: 3556-42

Squeezing of radiation in multiwave mixing processes: use in high-quality telecommunication, pp.128-136

Author(s): Partha S. Gupta, Indian School of Mines,  
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Abstract: Squeezing of electro-magnetic field, which is a purely quantum phenomenon has attracted considerable attention owing to its low noise property with applications in high quality telecommunication. This quantum effect is expected to manifest itself in optical processes in which the nonlinear response of the system to the radiation field plays an important role. In this paper squeezing of electro-magnetic field in multi-wave mixing processes like Raman and hyper Raman processes and sum- frequency generation are investigated under short-time approximation. The coupled Heisenberg quantum mechanical equations of motion for field operators are set up and solved under short-time approximation. The occurrence of squeezing of field is investigated using the required conditions of squeezing in each of the cases. The squeezing is found to exist in the fundamental mode and the squeezing in the generated field depends on squeezing in the fundamental mode. Squeezing in the higher order amplitudes are also studied. This corresponds to the squeezing of the variables which describe the real and imaginary parts of square and cube of the complex amplitudes of the radiation field. The higher order multimode sum-squeezing of radiation field is dealt with for harmonic and sum frequency generation. It is shown that squeezing in the sum frequency field depends directly on the sum squeezing of fundamental modes. The results can be utilized in selecting a suitable material and suitable process which will generate a radiation field with optimum squeezing and can be useful in high quality tele-communication. !10

Paper #: 3556-25

Theoretical analysis of quasi-phase-matched second-harmonic generation in poled fiber, pp.137-141

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Abstract: Recently high second-order nonlinearities were observed in glass fiber by a variety of techniques: thermal poling, corona poling, and electron implantation. This discovery suggested that the use of such a fiber may be as a practical frequency doubler, and as a suitable



replacement for more traditional but expensive, nonlinear crystal. More recently, periodically patterned second order nonlinearities have been created in optical fibers by thermal poling in vacuo and cw quasi-phase-matched second harmonic generation to the blue has been demonstrated. In this article we will present a mould for QPM SHG in poled fiber. The analysis is based on the coupled-mode theory and the nonlinear coupled mode equations were derived to describe second harmonic generation in poled fiber with periodic  $\chi^{(2)}$ , approximate solutions based on the no pump depletion approximation were given and discussed. The results are summarized in graphic data with normalized parameter. These results may be helpful in the design of practical fiber SHG devices. !7

Paper #: 3556-26

Effective nonlinear coefficients and quasi-phase-matched harmonic generation, pp.142-146

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Abstract: We have studied the harmonic generation and the effective nonlinear-optical coefficients of the quasi-periodic optical superlattice (QPOS). It has been shown that the effective nonlinear-optical coefficients in QPOS are the extension of that in periodic optical superlattice (POS). The intensities of the harmonic generation obtained by the coupled-wave equations are in good agreement with prediction by the effective nonlinear-optical coefficients. !14

Paper #: 3556-27

Electroluminescence and photoluminescence from heavily carbon-doped GaAs, pp.147-151

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Abstract: Electroluminescence (EL) and photoluminescence (PL) have been measured from thin layer structures of heavily carbon-doped GaAs film, with order  $10^{20}$  cm<sup>-3</sup> hole concentration, grown on semi-insulating GaAs substrate by metalorganic molecular beam epitaxy. The EL is detected only when the film contact is biased positively. The EL peak wavelengths at 80 K and 300 K occur at 900 nm and 950 nm respectively. The PL is measured at 3 K, 12 K, 80 K and 300 K, with peak wavelengths at 869.5 nm, 871.4 nm, 875.1 nm and 911.8 nm respectively. The EL spectra indicate that there are heterojunction interface states at about 50 meV below the conduction band. The PL of as-grown sample can be explained by band-to-band recombination in the heavily carbon-doped GaAs, and the

PL of annealed sample arises from recombination centers, formed by C $\delta$ -Ga $\delta$ / donors, in band gap. !17

Paper #: 3556-28

Femtosecond transient transmission studies of GaAs thin film, pp.152-155

Author(s): Feipeng Pi, Guangzhou Normal Univ., Guangzhou, China.

Abstract: Femtosecond transient transmission measurements are used to investigate the scattering and relaxation dynamics of nonequilibrium carriers in GaAs thin film. With a nonequilibrium energy-balance model, the cooling process of hot carriers via emission of phonons is simulated. It is found that, the fitting parameter  $\lambda$  is close to the Frohlich constant  $\alpha_F$  qualitatively and decreases with increasing excited carrier density. It reveals that the carrier-LO phonon coupling is the main way of the cooling of hot carriers and the coupling will be weakened by the nonequilibrium phonon effect. !10

Paper #: 3556-45

K2Al2B2O7: a new nonlinear optical crystal, pp.156-161

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Abstract: A new NLO crystal K $\delta$ -2 $\delta$ /Al $\delta$ -2 $\delta$ /B $\delta$ -2 $\delta$ /O $\delta$ -7 $\delta$ / (Potassium Aluminum Borate, KAB) has been discovered. The material crystallizes in the Trigonal system with a equals 8.5669(8) Angstrom, C equals 8.467(1) Angstrom and Z equals 3, KAB possesses similar space arrangement of SBBO. KAB crystal with dimensions of 18  $\times$  14  $\times$  3 mm was grown by flux method. The optical properties of KAB was measured. !9

Paper #: 3556-29

Structural characteristic of GaAlAs multi-epitaxial layer heterostructure, pp.162-165

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**Abstract:** GaAlAs/GaAs hetero-epitaxial thin films are prepared by liquid phase epitaxy (LPE) technique. Structural characteristic of the film was Studied by X-ray double crystal rocking curve method. We have measured the rocking curve of (400) reflection and observed the interference fringes. Computer simulation of the experimental curves have been performed with kinematical and dynamical diffraction theory, respectively. We discussed the reason for the appearance of the interference fringe, and calculated structure parameters. The results obtained using dynamical theory is closer to the actual growth parameters. !5

Paper #: 3556-30

Carrier tunneling in ZnCdSe/ZnSe asymmetric double-quantum-well structure, pp.166-169

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**Abstract:** Optical characteristics of ZnCdSe/ZnSe asymmetric double- quantum-well structure grown by LP-MOCVD were studied. By analyzing the photoluminescence spectra, we found that the excitation power and temperature could influence the tunneling of the excitons, and due to different tunneling time of electrons and holes, space-charge effect was observed. !5

Paper #: 3556-31

Photoluminescence of GaAlAs/GaAs quantum wells grown by metalorganic chemical vapor deposition, pp.170-172

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**Abstract:** In this paper we will report GaAlAs/GaAs gradient refraction index separate confinement quantum wells structures by MOCVD growth and its optical properties. The sample were characterized by high-resolution photoluminescence measurements. For 8 nm single quantum well, the excitation luminescence spectra at 10 K are characterized by transitions which has a linewidth (FWHM) of 6.2 nm and large intensity, indicating abrupt GaAlAs/GaAs interface. The shift of X(e-hh) peak position versus the excitation level are also observed. The results of PL measurement show that sample quality has met the requirement of design and proven to be satisfactory. !5

Paper #: 3556-32

Theory and modulator of multiple-dimensional acousto-optic interaction, pp.173-181

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**Abstract:** In this paper two-dimensional and multiple dimensional acousto-optic interactions are studied. The sets of coupled wave equations of multiple dimensional acousto-optic diffraction with multiple acoustic waves along different directions is put forward and its solutions are derived. The characteristics of the diffraction efficiency, compression, cross modulation, and intermodulation intensities are analyzed theoretically. The theoretical results are supported by experimental measurements through our new type of multiple directional acousto-optic modulators. !9

Paper #: 3556-33

Growth of Yb-doped fluorapatate crystal and study of its defects and spectroscopy performance, pp.182-188

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**Abstract:** We have successfully grown Yb:FAP(fluorapatite) crystal doped with 1 - 5 at% Yb by CZ technique. Crystalline boules which are colorless and transparent have the size of 22 mm in diameter and 45 mm in length. The optimal growth parameters are presented. During a Yb:FAP crystal growth run there exists a continuous loss of fluoride through evaporation, so 5% excess of calcium fluoride was usually added. To eliminate the defects, a post-annealing method has been developed where the boule is suspended above the melt surface for two days in a temperature zone that is about 400 degrees Celsius below the melting point. The defects of crystals were discussed, and the spectroscopy performances of Yb:FAP crystal were reported. !11

Paper #: 3556-34

Novel low-threshold all-optical switch, pp.189-196

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**Abstract:** We propose an all-optical switch that is composed of a symmetric Y-branch ion-exchanged glass waveguide with a strip of self-focusing polymer loaded on top of one branch and a strip of self-defocusing polymer loaded on top of the other branch. In terms of Jacobian elliptic functions, the nonlinear dispersion to explain the evolution of TE modes in the device was calculated. It is shown that the device can be used at relatively low input intensities. The factors affecting input power threshold and switching response of nonlinear wave propagation in the device are investigated in detail. To demonstrate nonlinear switching behaviors further, we employ a beam propagation method to simulate optical-field propagation in the Y-branch waveguide. !11

Paper #: 3556-35

Reverse saturable absorption mechanisms in chloro-aluminum phthalocyanine solution characterized by Z-scan, pp.197-209

Author(s): Tai-Huei Wei, National Chung-Cheng Univ.,  
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**Abstract:** Using the Z-scan technique with 532 nm laser pulses of

dual durations in the picosecond regime we distinguished two photon absorption and excited state absorption that contribute to the reverse saturable absorption in chloro-aluminum phthalocyanine dissolved in methanol. !9

Paper #: 3556-43

Noncritically phase-matched frequency conversion in  $\text{Gd}_{x\text{Y}1-x}\text{Ca}_4\text{O}(\text{BO}_3)_3$  crystal, pp.210-213

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Abstract: A nonlinear optical crystal  $\text{YCa}_{4-x}\text{O}(\text{BO}_3)_3$  (YCOB) is phase-matchable for third harmonic generation (THG) of a Nd:YAG laser by type-I mixing between 1.064 and 0.532 micrometer. By partial substitution of Gd for Y in YCOB, a solid solution  $\text{Gd}_x\text{Y}_{1-x}\text{Ca}_4\text{O}(\text{BO}_3)_3$  gradually changes the phase-matching angles of THG to  $(\theta, \phi)$  equals (90 degrees, 90 degrees). In this paper, we present the properties of noncritically phase-matched THG in  $\text{Gd}_x\text{Y}_{1-x}\text{Ca}_4\text{O}(\text{BO}_3)_3$  (x equals 0.24). !6

Paper #: 3556-36

Theory about coupled wave equations of acousto-electro-optic effect, pp.214-217

Author(s): Kuanxin Yu, Beijing Polytechnic Univ., Beijing, China;  
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Abstract: In this paper coupled wave equations of acousto-electro-optic (AEO) effect are proposed. These equations are based on coupled wave equations of electro-optic (EO) and acousto-optic (AO) effects. A formula of diffraction efficiency of the AEO effect is given through solving these equations. !4

Paper #: 3556-37

Two-dimensional logical operation with Bisox optical modulator, pp.218-221

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Abstract: An optical modulator is constructed from a thin water of bismuth silicon oxide, a displaying both photo-conductivity and the liner electro-optic effect. By the suitable use of selective erasure and regular baseline subtraction, with the optical modulator we have performed five logical operations: OR, NOT, NAND, NOR, NXOR. The experimental results are given. !3

Paper #: 3556-38

Effects of the third-order parametric process in optical fiber, pp.222-225

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Abstract: The degenerated four wave mixing (FWM) and the degenerated optical parametric amplifying (OPA) process near the zero dispersion are analyzed in this article. The gain bandwidth in OPA is about 35 nm. There is a dispersion threshold  $D_{th}$  in FWM which is not critically zero, but slightly positive about  $10\$/\$MIN@3\$/ps/nm.km$ . !4

Paper #: 3556-39

Matrix/vector multiplication by use of a two-dimensional multichannel acousto-optic device, pp.226-228

Author(s): Shiya He, Beijing Polytechnic Univ., Beijing, China;  
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Abstract: The method to perform matrix/vector multiplication using the acousto-optic (AO) processor has been studied in some earlier publications. This processing architecture provides high speed and high accuracy calculation. However, in the system, two AO devices must be used. For this reason, the optical couple between the two devices has to be adjusted carefully. It will cause the inconvenience and unsteadiness. A novel two-dimensional multichannel acousto-optic device is presented in this paper. By use of this kind of device, the trouble which the earlier architecture suffered from is got rid of and the experiment system is simplified. !3

Paper #: 3556-40

Controlling chaos of optical second-harmonic generation,  
pp.229-232

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Abstract: The paper performs a numerical investigation of controlling chaos in optical second-harmonic generation system. Using a method of variable delaying feedback to control chaos of the optical second-harmonic generation system, we have found that chaos is controlled effectively. We give the method of locating controllable parameters' regions. With the analysis of maximal Lyapunov exponent of the system, it is found that, suitable delay time and feedback stiffness can make chaos be controlled so as to stabilize the system. The orbits of the controlled system are the unstable orbits in the chaotic attractor of initial system. !12

Paper #: 3556-41

Stability and chaos of optical second-harmonic generation,  
pp.233-238

Author(s): Xihe Zhang, Beijing Institute of Technology,  
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Changchun Institute of Optics and Fine Mechanics,  
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Abstract: A numerical analysis for stability and chaotic behavior of second-harmonic generation (SHG) system with a Fabry-Perot (F- P) cavity pumped by variable laser fields is performed. Under some kinds of external modulated field, the effects to stability of the system are studied. The analysis curves of maximal Lyapunov exponent (MLE) of SHG via modulate field parameters are presented. It is found that not only the intensity and period but also the waveform of the pumping field can affect the stability and optical chaotic behavior of SHG. !9

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